MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2017/2018

EME1046 – PRINCIPLES OF THERMODYNAMICS

(ME)

21 OCTOBER 2017
2.30 p.m. –4.30 p.m.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This question paper consists of 5 printed pages (including cover page and appendix) with five questions.
2. Attempt **ALL FIVE** questions. Each question carries 20 marks.
3. Please write all your answers in the Answer Booklet provided.
4. All necessary workings must be shown.
5. A property tables booklet is provided.

Question 1

a) Define the following:
   i) Thermodynamics. (1 mark)
   ii) Internal energy. (1 mark)
   iii) Saturation temperature, $T_{sat.}$ (1 mark)
   iv) Mechanical efficiency. (1 mark)
   v) Mass flow rate. (1 mark)

b) Determine the missing properties by Complete the **Table Q1(b)** below for water H_2O:

Table Q1(b)

T [°C]	P [kPa]	h [kJ/kg]	x	Phase Description
	325		0.4	
160		1682		
	950		0.0	
80	500			
	800	3161.7		

(15 marks)

Question 2

a) A closed system undergoing a thermodynamics cycle consisting of four processes in series. The following **Table Q2(a)** gives partial data, in kJ. For the cycle, the effects of kinetic and potential energy can be ignored.
Determine the following:

   i) Missing table entries, each in kJ. (6 marks)
   ii) The network output during the cycle. (2 marks)
   iii) The net heat input during the cycle. (2 marks)

Table Q2(a)

Process	ΔU (kJ)	Q(kJ)	W(kJ)
1-2	600		-600
2-3			-1300
3-4	-700	0	
4-1		500	700

Continued ...

b) A piston–cylinder device contains 0.2 kg of water initially at 800 kPa and 0.06 m^3. Now 200 kJ of heat is transferred to the water while its pressure is constant. Determine the following:

i) Initial and the final temperature of the water (8 marks)
ii) Show the process on $T-v$ diagram with respect to saturation lines. (2 marks)

Question 3

Steam flows steadily through an adiabatic turbine. The inlet conditions of the steam are 6 MPa, 400 °C, and 80 m/s, and the exit conditions are 40 kPa, 92 percent quality, and 50 m/s. The mass flow rate of the steam is 20 kg/s. Determine

a) the change in kinetic energy, (5 marks)
b) the power output, (5 marks)
c) the turbine inlet area, and (5 marks)
d) the rate of entropy generation for this process. (5 marks)

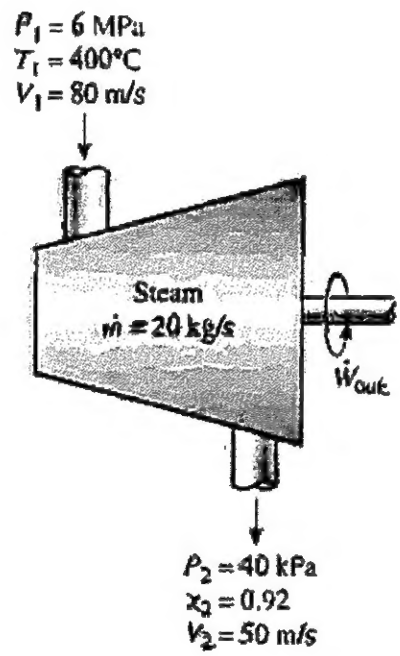

Figure Q3

Question 4

The Carnot cycle comprises sequentially: (i) a reversible isothermal expansion of a working substance in contact with a high-temperature reservoir at temperature T_H, (ii) a reversible adiabatic expansion to a final state having a temperature T_L equal to that of a low-temperature reservoir, (iii) an isothermal reversible compression in thermal contact with the low-temperature reservoir, (iv) a reversible adiabatic compression returning the working substance to its initial state.

a) Sketch the above cycle on a PV indicator diagram, labelling each step (i)-(iv).

(5 marks)

Continued ...

b) What is the direction of heat transfer for each step of the cycle? (2 marks)

c) By considering the working substance in a Carnot cycle to be an ideal gas show that the heat removed from the hot reservoir per cycle Q_H and heat transferred to the cold reservoir per cycle Q_L are related by

$$\frac{Q_L}{Q_H} = \frac{T_L}{T_H}$$

You may use without proof that $TV^{\gamma-1}$ is constant for reversible adiabatic changes of state of an ideal gas. (7 marks)

d) The following heat engines produce power of 95 MW. Determine in each case the rates at which heat is absorbed from the hot reservoir and discarded to the cold reservoir.

i) A Carnot engine operates between heat reservoirs at 750 K and 300 K.

ii) A practical engine operates between the same heat reservoirs but with a thermal efficiency of 0.35.

(6 marks)

Question 5

a) An inventor claims that his heat engine receives 1000 kW of heat at a constant temperature of 285 °C and rejects 492 kW of heat at 5 °C. Check the validity of the claim by consider the rate of entropy generation for this engine.

(5 marks)

b) An insulated 5 m^3 rigid tank contains air at 500 kPa and 57°C. A valve connected to the tank is now opened, and air is allowed to escape until the pressure inside drops to 200 kPa. The air temperature during this process is maintained constant by an electric resistance heater placed in the tank. Determine

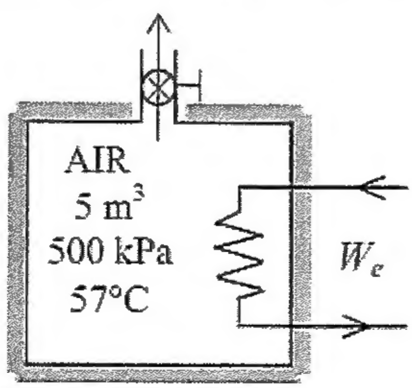

Figure Q5

i) the mass of the air escaped from the tank, (5 marks)

ii) the electrical energy supplied during this process, (3 marks)

iii) the total entropy change. (7 marks)

Continued ...

Appendix

Uniform State Uniform Flow (Unsteady Flow)

Continuity:

$$\sum_i m_i - \sum_e m_e = (m_2 - m_1)$$

First Law:

$$Q_i + W_i + \sum_i m_i\left(h_i + \frac{V_i^{\,2}}{2} + gZ_i\right) - Q_e - W_e - \sum_e m_e\left(h_e + \frac{V_e^{\,2}}{2} + gZ_e\right)$$
$$= m_2\left(h_2 + \frac{V_2^{\,2}}{2} + gZ_2\right) - m_1\left(h_1 + \frac{V_1^{\,2}}{2} + gZ_1\right)$$

Second Law:

$$\sum_i m_i s_i - \sum_e m_e s_e + \int_0^t \frac{\dot{Q}_{cv}}{T}\,dt + S_{gen} = m_2 s_2 - m_1 s_1$$

Ideal Gas

Ideal Gas Equations of State

$$Pv = RT$$
$$dh = C_p dT$$
$$du = C_v dT$$

Specific Heats and Ideal Gas Constants

$$C_p - C_v = R$$
$$\frac{C_p}{C_v} = k$$

Entropy Relationships

$$s_2 - s_1 = C_v \ln\frac{T_2}{T_1} + R\ln\frac{v_2}{v_1} \quad \text{if constant } C_v$$
$$= C_p \ln\frac{T_2}{T_1} - R\ln\frac{P_2}{P_1} \quad \text{if constant } C_p$$
$$= s^0_{T_2} - s^0_{T_1} - R\ln\frac{P_2}{P_1} \quad \text{otherwise}$$

For polytropic process

$$PV^n = c$$
$${}_1W_2 = \frac{P_2V_2 - P_1V_1}{1-n} \quad n \neq 1$$
$$= P_1V_1 \ln\frac{V_2}{V_1} \quad n = 1$$

End of Paper.